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TRENS IN THE WORLD PRODUCTION OF NATURAL FIBERS OF ANIMAL ORIGIN- SILK AND WOOL

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Abstract

The paper analyzed the trends in natural fiber production pointing out the changes in silk and wool production, export and import worldwide and in the main producing, exporting and importing countries in the period 2007-2018 using official statistical data which were processed using Fixed Index, Trend Method based on polynomial and linear models, Descriptive statistics, and comparisons. The production of natural fibers was 111.3 million tons, representing 35 % of the global fiber production. Cotton accounts for 80 % of the natural fiber output, while wool 3.3% and silk 0.2 %. The demand for natural fibers is increasing due their special qualities which satisfy the best people desire to wear and use natural things and the large range of products which could be obtained. In 2018, the world silk output was 159,648 metric tons by 32.11 % more than in 2007. China and India produce 97.19 % of the world silk output, and also are exporting and importing countries. The USA, Italy, Japan, India, France, China, United Kingdom, Switzerland, Germany are the principal importing countries. The global wool production (clean) declined from 1,202 thousand tons in 2007 to 1,155 thousand tons in 2018, due to the reduction of sheep population and new orientation to meat production. The main wool (clean) producing countries are: Australia, China, New Zealand, CIS, Argentina, United Kingdom, South Africa and Uruguay. The consumption is represented by 48 % apparel wool, 31 % interior textiles and 21% industrial wool. Australia exports garments, sweaters, men suits and women overcoats, China exports yarn and knitwear, Italy is the 2nd exporter of wool yarn, fabric, men's and women's woven wear and knitwear, India is the largest exporter of carpets and rugs, the United Kingdom is profiled on fabric, knitwear, women's wear and carpets. The main importing countries of wool products are: the United Kingdom, Italy, the USA, Japan, China, Australia, and Germany. As a conclusion, natural fibers of animal origin are desired by consumers and their increasing demand stimulates producers and traders to intensify their business to better satisfy clients' needs.

Key words**:** *silk, wool, world production, main producing, exporting and importing countries, trends*

INTRODUCTION

Natural fibers are produced by plants, animals, and geological processes [43].

FAO classifies natural fibers in two categories: ***(i) Plant fibers*** subdivided into three sub classes: *seed hairs* including: cotton, stern (bast) fibers (flax and hemp); *leaf fibers:* sisal etc; *husk fibers*: coconut; ***(ii) Animal fibers:*** wool, hair and secretions (silk) [16].

Another classification divides natural fibers into three categories: (i) ***Cellulose/lignocellulose fibers***, including: *Bast:* flax, hemp, jute, kenaf, ramie; *Leaf*: abaca, banana, pineapple, sisal; *Feed*: cotton, kapok; *Fruit:* coir; *Wood*: hard and soft wood; *Stalk*: wheat, maize, oat, rice; *Grass/reed*: bamboo, corn. (ii) ***Animal fibers***, divided into: *Wool/hair*: cashmere, goat hair, horse hair, lamb wool; *Silk*: Mulberry silk produced by silk worms, but also by other types other insects. (iii) ***Mineral***: asbests, ceramic fibers, metal fibers [48].

Natural fibers have been and still are important in our life and economy grace to their qualities: naturalness, comfort, breathability, pleasant touch, resistance, durability, elasticity, sensitivity to water and heat, biodegradability, friendly with the environment, and multiple uses [68].

However, the actual market is invaded and dominated by the artificial synthetic fibers whose production cost is low, the synthetic products have a selling price which assures a high profit to producers and also is suitable to

the consumers' pockets**.** In 2013, of the world fiber production, about 65 % were represented by synthetic fibers and 35 % by natural fibers, accounting for 33 million tons, of which the highest share, 30.4 %, i.e. 26 million tons, belonged to cotton, and just 1.3 % to wool and 0.2 % to silk [63, 71]. According to DNFI, Production of Fibers 2008-2018, Bremer-Baumwolle Börse, in 2018, the world fiber production was estimated at 111.3 million tons, by 50.3 % more than in 2008, when it was 74 million tons. Of the global fiber production in 2018, natural fibers production accounted for 32.2 million tones being by 9.2 % higher than in 2008. In the interval 2008-2018, it was appreciated that the share of the global natural fiber production in the world fiber output declined from 39.8% in 2008 to 28.9% in 2018 (Table 1).

Table 1.The natural fiber production by fiber type in 2018 versus 2008

	2008		2018		2018/2008 Growth rate (%)
	Production (Thousand tons)	Share (%)	Production (Thousand tons)	Share (%)	
World fiber production	74,024	100.0	111,300	100.0	150.3
World natural fiber production	29,479	39.8	32,200	28.9	109.2
of which:					
Raw cotton	23,584	80.00	26,120	81.12	110.75
Jute, kenaf etc	2,588	8.78	2,500	7.76	96.59
Dried wool	1,198	4.06	1,080	3.35	90.15
Cocos fiber	1,056	3.58	970	3.01	91.85
Linen	533	1.80	310	0.96	58.16
Sisal etc	296	1.00	210	0.65	71.18
Raw silk	164	0.55	164	0.5	100.00
Hemp	61	0.20	70	0.22	114.75

Source: Own adaptation based on the data from [20].

As observed, in 2018, the contribution of various types of natural fibers to the global production was: 81.12 % cotton, 7.76 % jute, kenaf etc, 3.35 % dried wool, 3.01 % cocos fiber, 0.96 % linen, 0.65% sisal, 0.5 % raw silk and 0.22 % hemp. Compared to 2008, in 2018 it was expected an increase by +10.75 % for cotton, +14.75 % for hemp and stable level for silk, and a decrease in case of wool by -9.85 % and also in case of linen, sisal, cocos, jute and kenaf.

In this context, when the demand for natural fibers is increasing, the paper aimed to study the dynamics of production for the natural fibers of animal origin: silk and wool in the period 2008-2018 in order to identify the main trends at the global level and in the main producing exporting and importing countries.

MATERIALS AND METHODS

For setting up this paper it was needed to use empirical data provided by various official international and national data bases such as: FAOSTAT, Eurostat, International World Textile Organization, INSERCO, NSW Government, Wool Industry, Department of Primary Industry, Economic Service, Statistics of New Zealand, USDA, American Sheep Industry Association, China National Bureau of Statistics etc, the period of analysis being in general 2007-2018, but also 2008-2018 depending of the availability of the data sources.

The aspects analyzed in this study have been:

(i)The importance of silk and wool and their qualities which justify production;

(ii)The main sorts of silk and wood products achieved and commercialized as well;

(iii)The dynamics of raw silk and wool production (greasy and clean) at the world level;

(iv)The main producing countries of silk and wool and their share in the global production;

(v)The main exporting and importing countries of silk and wool products worldwide.

The aspects mentioned above were studied using the following methods:

-***Fixed Index Method*** to point out the increase or decrease in the final year compared to the basic year of comparison;
-***Trend Method*** to identify the tendency in the studied interval by means of the graphic illustration of the polynomial regression equation: $Y = ax^2 + bx + c$ and linear regression equation, $Y = bx + a$ as well as the coefficient of determination, R^2.
-***Descriptive statistics*** including mean, standard deviation and the coefficient of variation.
-***Structural analysis*** to show the contribution of different countries to the world production, export and import.
-***Comparison method*** was used to analyze the differences among various producing, exporting and importing countries.
The results are presented in tables and illustrated in graphics, of which just a part are included in this article.

RESULTS AND DISCUSSIONS

Silk Production

Silk is a natural fiber consisting of fibroin 75 %, sericin 22.5%, fat and wax 1.5%, ash 0.5% and salts 0.5% [5].
Silk is produced by silk worms and also by other insects such as: spiders, crickets, bees, ants etc. Therefore, silk is of various types and quality, the best one being considered from silk worms fed with Mulberry leaves [65]. Silk is named "the queen of textiles" as it has been and still is a raw material for producing elegant and luxury clothes (blouses, dresses, suits, skirts, shirts, trousers, dressing gowns, bathrobes, house coats, jackets, blazers, sports-wear etc), accessories (ties, scarves, gloves, collars etc) and house textiles such as: carpets, draperies, wallpapers, furniture covers, blankets, bed sheets, table cloths etc. Also, silk is useful in medicine for catgut used in surgery, in aeronautics for parachutes, in electronics as insulation coils etc [56, 74].
Silk is appreciated very much for its special qualities such as: aesthetic aspect, fineness, pleasant touch, natural brightness, light weight, toughness, durability, high absorbance capacity, isothermal properties and affinity for dyes [3, 11].
Silk is also important because the highest part of its production comes from silk worms which are easily grown in small family farms. Sericiculture is an agricultural activity with a beneficial impact on rural population in many countries. Silk worms rearing needs just small investments, a summary endowment and equipment, work is suitable both for men, women and children, mulberry trees could be cultivated on various soil types and climate areas (temperate, sub tropical and tropical). Therefore, silk worms growing reduce unemployment and migration to cities, involves low production costs, provides a satisfactory income, contributes to the development of the rural economy, assures environment protection and biodiversity preservation being an eco-friendly activity. Silk industry has been developing due to the high demand which creates opportunities for the growth of international trade. The producing countries of raw silk are interested to carry out a higher production and to intensify their deliveries to the processing industry. For the emerging economies, silk production contributes to the alleviation of poverty and improving the living standard of the population [3, 10, 26].
Of the total amount of global natural fibers, silk represents just 0.2 %, but its output is largely spread in more than 60 countries, most of them being situated in Asia (China, India, Uzbekistan, Koreas, Thailand, Vietnam, Japan and Turkey, but also in South America (Brazil), Africa (Egypt and Madagascar) and Europe (Bulgaria, Italy, Spain) [27, 74].
In 2018, the world silk production accounted for 159,648 metric tons being by 32.11 % higher than in 2007. During the period 2007-2018, silk production registered variations ranging between the minimum level of 105,278.94 metric tons in 2009 and the maximum level of 202,072.88 metric tons in 2017 (Fig.1). The average of the global silk production in the analyzed interval was 153.03 thousand metric tons, the standard deviation was +8.89, and the coefficient of variation accounted for 5.8 %.

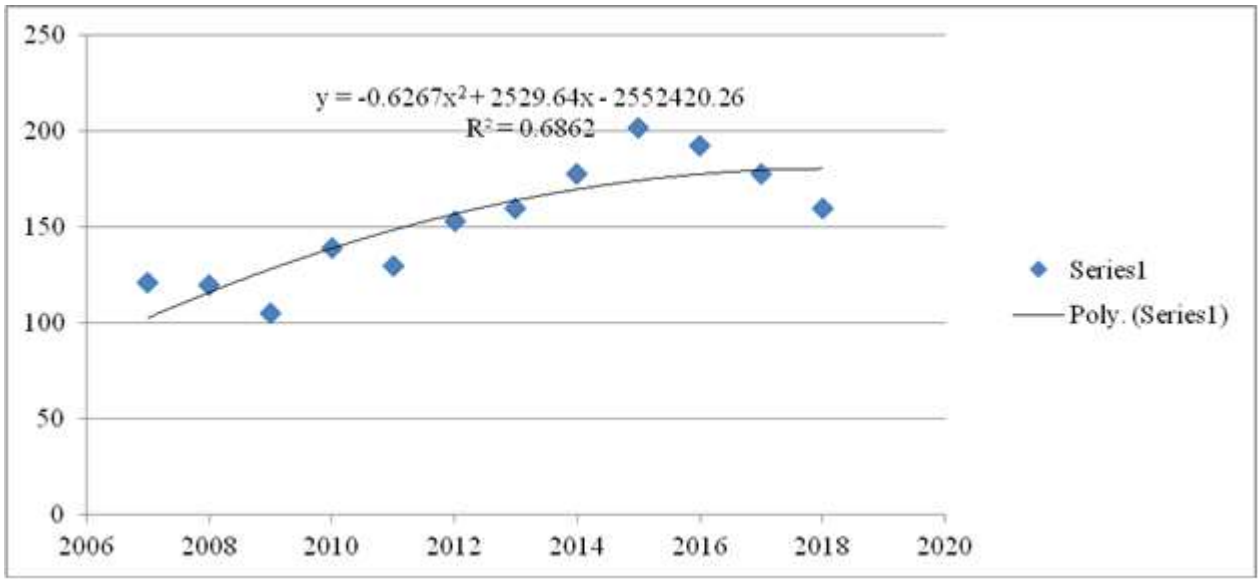

Fig.1.Dynamics of world silk production, 2007-2018 (Thousand Metric Tons)
Source: Own design based on the data from [27, 29].

The main producing countries in 2018 have been, in the decreasing order: China, India, Uzbekistan, Thailand, Vietnam, Brazil, North Korea, Iran, Turkey and Japan. The most substantial contribution to global silk production have China and India, which together produced 155.26 thousand metric tons, representing 97.19 % of the world output (Table 2).

Table 2. The contribution of the main silk producing countries to the global silk production, 2018 (Metric tons; %)

	Silk Production (Metric tons)	Share (%)
World	159,548	100.0
China	120,000	75.11
India	35,261	22.08
Uzbekistan	1,800	1.12
Thailand	680	0.42
Vietnam	680	0.42
Brazil	650	0.40
North Korea	350	0.21
Iran	110	0.06
Turkey	30	0.02
Japan	20	0.01
Total		99.84

Source: [29].

China is the major silk producer at the global level and also a silk exporter. ***India*** is also both a producing and exporting country, but it on the top position as a silk importing country, while China is the top exporting country at the global level.

The international trade with silk is facing a higher and higher competition among the Asian countries and also between the Asian countries and the rest of the world.

China's export is represented mainly by final products sold to the USA, and yarn, fibers and woven fabrics to India. But, China also imports silk from India.

India's exports consist especially of pure silk fabrics, silk filament and raw silk, therefore, less processed products, and imports bring yarn and fibers and woven fabrics on the internal market from China. The exchange of silk products between China and India is not balanced, as Chinese export exceeds India's export, and more than that, silk price in the Indian market is higher than in China, advantaging the Chinese companies and disadvantaging the Indian farmers and processors [25].

India is country producing four types of silk: 89 % Mulberry, 8 % Eri, 1.9 % Tasar, and 0.6% Muga, for the last one India keeping the monopoly [2].

Indian silk and silk products are also required in the international market, and silk yarn and fabrics are the major products imported by this country [4, 10, 44].

In 2019, India produced more Mulberry silk, representing 95% of its total raw silk production. India's exports are mainly oriented to Germany, Italy, the USA and

Turkey, while its imports are coming from China as mentioned above and consists especially of raw silk and other fibers, basic fabrics and garments [11].

Sericin and pupae are also successfully carried out and commercialized by the producing countries [3].

The USA, Italy, Japan, India, France, China, United Kingdom, Switzerland, Germany and United Arab Emirates are the principal importing countries of silk products in the world [29].

The USA is the top importing country of Indian silk products (yarn, fabrics, made-ups, and RMG).

Italy and France prefer to import raw silk, silk yarn, but also silk garments. In general, they are importers of raw silk but high-quality processors.

Italy has a high developed industry specialized in silk processing (finishing, dyeing and printing silk fabrics). Italian silk neckties and scarves are well known in the world for their high quality.

France has also a well developed silk processing industry producing especially clothing and also silk fabrics have started to be used for interior decorations (wall covers, curtains, bed spreads, upholstery) which are well sold on the internal market but also in the USA.

Germany imports especially garments, accessories and interior textiles from China, India and Thailand.

Japan is an important importer of silk merchandises; more than 50 % silk being used especially for kimonos. The imports are coming from China and Brazil [64].

Europe has not an important contribution to the world silk production, the only silk producing country being Bulgaria whose production is very small but it increased from 8 metric tons in 2014 to 10 metric tons in 2018 (+25%). The share of Bulgarian silk in the global silk production is non significant, just 0.00627 %.

The EU is a silk importer as in Italy, France and Spain silk processing industry is well developed.

The silk trade in Europe is run by a few countries. Among the top silk exporting countries in the world it is China with the highest market share (54%), Italy (13.5%), India (4.2%), Romania (4%) and France 93.8%), all these five countries summing 80 % of the world silk export value.

The most exported silk products in the world are: woven fabrics, raw silk non thrown, silk waste, silk yarn and yarn spun from silk waste [53].

In 2016, the value of world silk export was USD 2.1 Billion by 31.4% lower than in 2012, while the global silk import reached USD 1.8 Billion, being by 29% smaller than in 2012.

The share of the most required silk products for import at the global level is: woven fabrics 57%, raw silk non thrown 23%, and silk yarn 13 %.

The top silk importing countries worldwide are: Italy, the top importer, with 18.5% market share, India 12%, Japan 7%, Romania 7%, China 7%, Vietnam 6%, USA 6%, France 5 %, Germany 3% [53, 56].

Romania had a developed sericulture keeping a valuable collection of over 60 silk worms races and hybrids and carrying out a high raw silk production. The silk pipeline from farm to the final product was well organized, silk processing industry was running well and the country made important exports [37, 39, 40].

At present, silk worms rearing is developed as a small business in small family farms, a part of them being vertically integrated from silk cocoons till the final product, because the industry along the pipeline failed since 2007. A part of the farms are endowed with reeling machines and then silk filament is transformed into traditional products, mainly handicrafts such as: rustic scarves or veils, peasant blouses named "ii", decorative products etc, which are preferred by the Romanians in the domestic market and abroad. Sericultural farms are economically efficient, production cost being covered by returns and assuring a satisfactory income for the silk worm breeders [38, 41,42, 50, 58, 59, 60, 61, 62].

At present, Romania has a good position in the international trade with silk, being ranked

the 4th both as a silk exporting country and as a silk importing country [57].

Wool production

From a chemical point of view, wool consists of keratin 33%, grease 28%, suint 12%, impurities 26%, and mineral water 0.1 % [6].

Wool is a natural fiber which contains pure organic carbon transformed from plants by sheep at the moment of feeding. As long as carbon is stored in wool or wool garments and other textiles, the atmosphere is protected against pollution and this mitigate climate change. Wool is also highly resistant, having a long lifespan, it is an eco-friendly fiber, being easily biodegradable and suitable for recycling [31].

Wool has a large range of properties, the main ones being: naturalness, fineness of touching, luxury aspect, comfort, durability, wrinkle resistance, color maintenance, protective against heat and cold, biodegradability, water absorption power, easy contamination [73].

Taking into consideration the diameter of the fiber, wool is classified into the following classes: fine wool having less than 24.5 microns, medium wool with a diameter ranging between 24.6 and 32.5 microns and coarse wool with over 32.5 microns' diameter.

Fine wool represents more than 50 % of the global wool production and is largely used in apparel, while medium and coarse wool is destined for interior textiles [32].

Wool is a raw material for processing industry which transforms it into a large range of products: woolen fabrics, worsted fabrics, clothes (suits, coats, pants, sweaters, dresses, shirts, skirts, gloves, mittens, collars, shawls, hats, toques, underwear, coat lining, shoes, socks, saddle clothes), interior goods (furniture coverings, blankets, carpets, rugs, upholstery, pillows, duvets, ornaments, slippers), tote bags, backpacks, dog coats, horse rugs etc [7, 47].

Wool is a fleece resulting from the sheered animals. The main species producing wool are sheep and goats (cashmere and mohair), but also camels (hair), rabbits (angora wool), alpacas (Huacaya fiber), llamas (fleece) and musk ox (qivint) [23].

Sheep population is responsible for the largest amount of wool produced in the world. "From one sheep, it could be obtained about 4.5 kg wool/year of which one produces 10 meters of fabric or six sweaters" [21, 30].

Wool production is sustained by sheep and goats grown in various countries, the highest number of sheep being in China, Australia, New Zealand, United Kingdom, South Africa, Brazil, Argentina, Peru and Uruguay.

In 2013, there were 1,206 million sheep in the world by 5.3 % less than in 1990, reflecting a decreasing trend due to the global warming which reduces fodder resources and the new orientation of breeders to meat production. In 2018, at the global level, there were 1,177 million sheep by 2.5 % less than in 2013, but by 2 million more than in 2017, reflecting a slight increase. The year 2018 is recognized as the year with the highest number of sheep since 1992 (Table 3) [33].

Table 3. The distribution of sheep by main growing countries in the world, 2018 (million heads, %)

	2013, World sheep number = 1,206 million heads	2018, World sheep number = 1,177 million heads
China	13.2%	14.0 %
Australia	6.6 %	6.0 %
New Zealand	2.7 %	2.0 %
United Kingdom	2.9 %	3.0 %
South Africa	2.2 %	2.1%
Brazil	1.3 %	
CIS	4%	8 %
India	2 %	5%
Turkey	2%	3%

Source: Own calculations based on the data from [17, 32].

The decline of the sheep livestock started in the year 2000, when global warming has become more present and showed its effects: long periods of droughts, less rainfalls, reduced fodder production, all these resulting in a diminished wool production, affecting sheep breeders income, raw wool inputs for processors and the price growth. This was the reason why sheep breeders moved to mutton and cotton production to survive [75].

However, wool demand and consumption continue to increase despite that production

trend was a sinuous one. Consumers are highly interested mainly in merino wool for its specific qualities such as: comfort, soft touching, breathability, elasticity, durability, which sustain exports and the compensation of the fall in wool price [23].

After the fall of wool market in 2018, by USD Billion since 2014, wool industry started to apply a new strategy involving more innovation and research for sustaining wool production. In 2019, it is expected as wool market to reach USD 35 Billion and in 2029 USD 48 Billion, taking into account the increasing trend in consumers' preference for natural fibers, despite of the invasion of synthetic fibers in the market. Always, high quality and luxury articles will be highly attractive for consumers with a refined taste and this encourage producers to do the best for satisfying their needs to wear natural healthy, comfortable and high quality clothes [73].

The world wool production (greasy) registered in general a descending trend, from 2,192.6 thousand tons in 2007 to 2,125.8 thousand tons in 2013, according to FAOStat, (Production, lack of data for the period 2014-2018), meaning by 3.1 % less. In the period 2007-2013, the maximum production was 2,192.6 thousand tons in 2007 and the minimum level was 2,021 thousand tons in 2010.

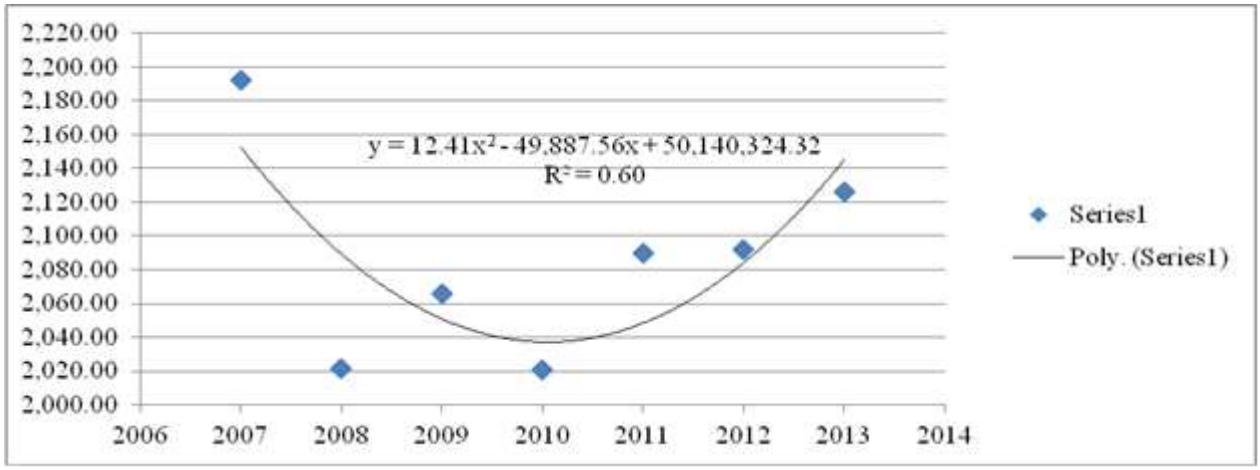

Fig.2. Dynamics of world wool production (greasy), 2007-2013 (Thousand tons)
Source: Own design based on the data from [18].

In 2013, the contribution of the main producing countries to the world wool production (greasy) was: China 22.1 %, Australia 16.9%. New Zealand 7.7 %, United Kingdom 3.2 %, Iran 2.9 %, Morocco 2.6 %, Russian Federation 2.5 %, Turkey 2.4 %, India 2.2 %, Argentina 2.1 %, summing 1,379.3 thousand tons, representing 64.88 5 of the global output (Table 4).

In 2015, the world wool output (greasy) accounted for 2,128 thousand tons, of which Australia 20.1 %, China 20.1 %, CIS 10 %, New Zealand 7.3 %, South Africa 2.3 %, Argentina 2.2 %, United Kingdom 1.4 % and Uruguay 1.3 % (Table 5).

Table 4. The contribution of the main producing countries to the world wool production (greasy), 2013 (Thousand tons)

	Wool production ((Thousand tons)	Share (%)
World	2,125.8	100.0
China	471.1	22.1
Australia	360.5	16.9
New Zealand	165.0	7.7
United Kingdom	68.0	3.2
Iran	61.5	2.9
Morocco	56.0	2.6
Russian Federation	54.6	2.5
Turkey	51.1	2.4
India	46.5	2.2
Argentina	45.0	2.1
Total	1,379.3	64.88

Source: Own calculation based on the data from [18].

The world wool production (clean) registered a general declining trend in the analyzed period from 1,202 thousand tons in 2007 to 1,155 thousand tons in 2018, meaning by 4% less. This was due to the dynamics of sheep livestock which also declined from 1,100 million heads in 2007 to 1,075 million heads minimum level in 2010, but then, it was noticed a slight recover so that in 2018, world sheep number accounted for 1,177 million heads (FAOStat, Poimena Delta Analysis, 2019) (Fig. 3). World wool production is not equally distributed in apparel and interior textiles. Since 2009, it was noticed a declining trend in apparel wool, while the interior textile wool was increasing till present [46].

Table 5. The contribution of the main producing countries to the world wool production (greasy), 2015 (Thousand tons)

	Share in the global wool production (%)
World wool production (Greasy)- Thousand tons	2,128
Australia	20.1
China	20.1
CIS	10.0
New Zealand	7.3
South Africa	2.3
Argentina	2.2
United Kingdom	1.4
Uruguay	1.3

Source: Own calculation based on the data from [18].

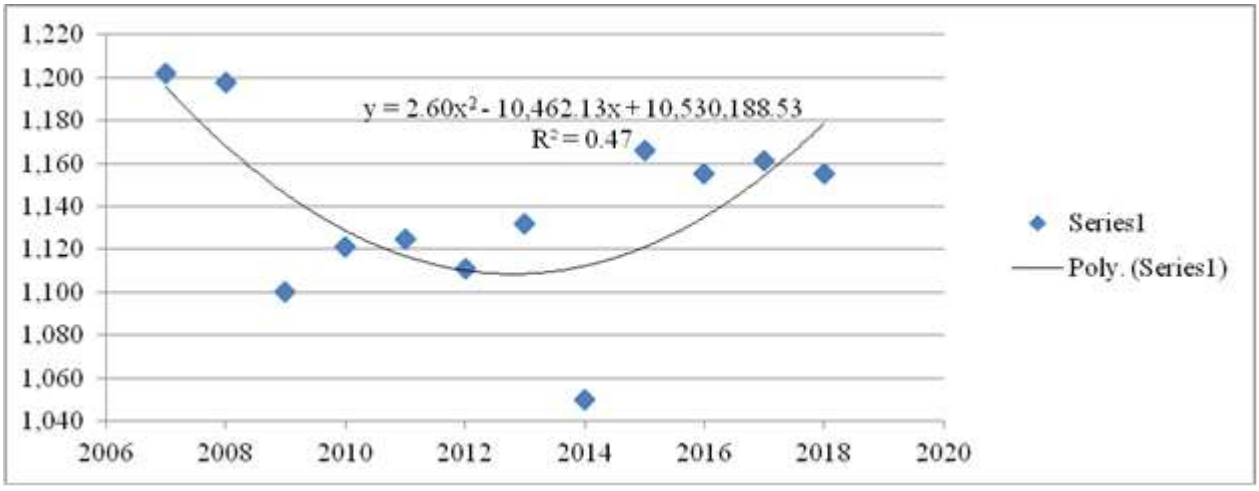

Fig.3. Dynamics of world wool production (clean), 2007-2018 (Thousand tons)
Source: Own design based on the data from [18].

In 2018, the weight of the main producing countries in the global wool production (clean equivalent) was: Australia 23.4 %, China 15.5%, New Zealand 9.1 %, CIS 11.4%, Argentina 2.3 %, United Kingdom 2.2 %, South Africa 2.2 % and Uruguay 1.6 %. Compared to the share recorded in 2007, it was noticed an increasing position in case of CIS from 7.5 % in 2007 to 11.4 %, a decline in New Zealand from 13.7% to 9.1 % and in Uruguay from 3 % in 2007 to 1.6 % in 2018 (Table 6).

Of the global wool production (clean), merino wool production represents 98.04 % in 2017, 98.8 % in 2018 and it is expecting to reach 98.95% in 2019 (1,143.1 thousand tons), by 0.42 % more than in 2017 (1,138.3 thousand tons) [76].

The main producing countries of Apparel wool of the world amount in 2018, accounting for 1,141.3 thousand tons, Australia produced 269.2 (23.5%), Argentina 25.9 (2.26%), South Africa 25.1 (2.19%), Uruguay 18.3 (1.6%0 and USA 6.4 (0.5%).

The main producing countries of interior textiles achieved in 2018: China 179 thousand tons (15.6%), New Zealand 104 (9.1 %), United Kingdom 25.8 (2.3%), India 33.4 (1.9%), and Mongolia 20.5 (1.7%) [34].

As a consequence of the higher and higher wool demand, in many countries, the wool textile pipeline is intensified and diversified in all its technological key points:"processing,

spinning, weaving, knitting, garments making and internal textile" [72].

Table 6. World wool production (clean) and the contribution of the main producing countries in 2007, 2008, 2012, and 2018 (%)

	World wool production (clean)- Thousand tons			
	2007*	2008**	2012***	2018****
WORLD	1,202	1,200	1,111	1,155
of which (%)				
Australia	25.0	24	21.8	23.4
China	14.8	15	15.1	15.5
New Zealand	13.7	13	11.1	9.1
CIS	7.5	8	10.6	11.4
Argentina	4.0	3	2.6	2.3
Uruguay	2.9	3	2.1	1.6
South Africa	2.3	2	2.5	2.2
United Kingdom	2.0	2	2.1	2.2

Sources: Own conception based on the data from [1****, 19***, 76*, 77**].

The consumption of wool fibers is distributed as follows: 48 % apparel wool, 31 % interior textiles and 21% industrial wool.

The main importing countries of processed wool are: China (64%), Italy (6.2%), India (5.5%), Germany (3.9%), and Czechia (3.4%) [1].

Australia is the leader producing country accounting for about 24% of the global wool output, whose value is about USD 3 Billion. However, in the period 2007-2018, the sheep flock declined by 21.2 % from 11,158 thousand heads in 2007 to 8,800 thousand heads in 2018 and in 2018 it is expecting to reach 7,400 thousand heads. As a result, wool production (grease) also declined by about 15 % from 450 tons in 2007 to 383 tons in 2018, due to the changes of the climate in Australia (Fig. 4) [14].

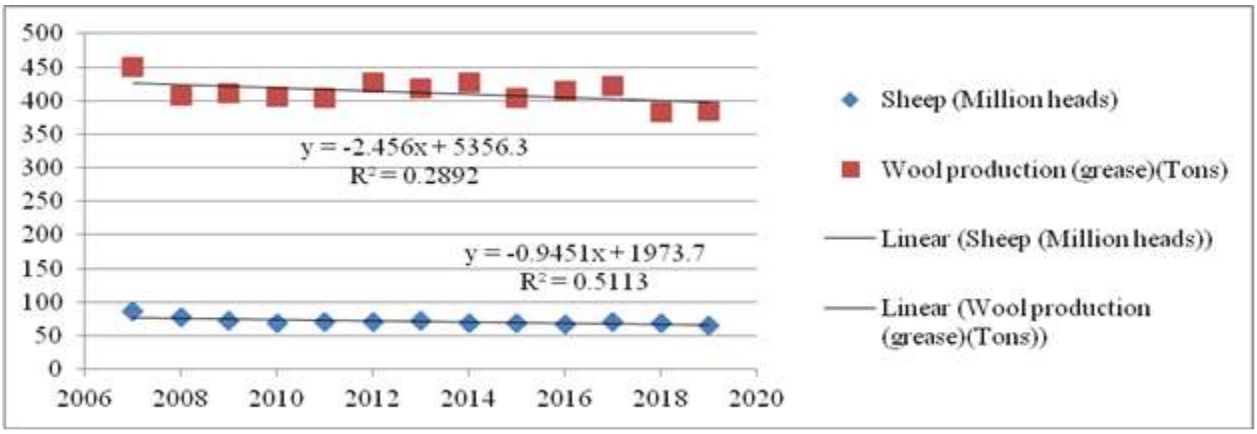

Fig.4.Dynamics of sheep flock and wool production (grease equivalent) in Australia, 2007-2019
Source: Own design based on the data from [14].

The main use of wool in Australia is for apparel [47].

Australia is the leader in merino wool producing about 77% of the global production of fine wool. Also, other countries like South Africa, Argentina and Uruguay contributes to the fine wool production in lower percentages: 11 %, 7 % and, respectively, 2 %.

Of the wool products exported by Australia, garments represent 45%, sweaters 38%, men suits 14% and women overcoats 13.8% [21].

China is ranked the 2nd for its contribution to the world wool production, but it comes on the 1st position for sheep population, whose number increased by 3.6% from 286 million heads in 2007 to 297.1 million heads in 2018, with a peak of 302.3 million heads in 2017.

This is due to the fact that sheep rearing is an important income source for the rural population [13].

While in China, sheep flock increased by 24.6% since 1990 till 2013 and also continued till 2018, in other countries sheep population decreased, being affected by climate change. It is about Australia, where in the period 1990-2013, the sheep flock declined by -56.4 %, in New Zealand by -46.7%, in Argentina by -58 % and in Uruguay by -67.2 % [12].

China's contribution to the world wool production is about 20 % and this proves that wool sector plays an important role in the economy. The main wool products exported by China are clothes and textiles [47].

Chinese wool quality does not compete with the Australian one. That is why about 65 % of China's import of wool comes from Australia and the remaining from New Zealand and Uruguay. China imports all the wool types [73].

New Zealand comes on the 3rd position among the top wool producing countries worldwide, having a market share of 11 %. Its production is distinguished by the high weight of wool blankets, yarn and upholstery [21, 47].

In New Zealand like in Australia, the sheep flock declined. In 2018, it accounted for 27,296 thousand heads being by 20.1 % smaller than in 2007 (38,460 thousand heads). And this diminished wool production by 37.8% from 224.5 tons in 2007 to 139.8 tons in 2018 (Fig. 5) [8, 9].

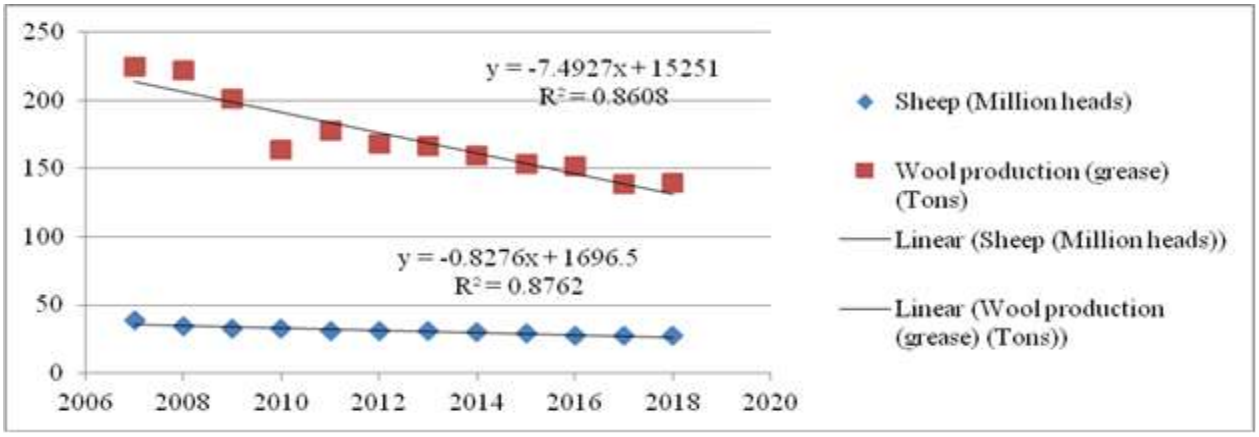

Fig. 5. Dynamics of sheep flock and wool production (grease equivalent) in New Zealand, 2007-2018
Source: Own design based on the data from [9].

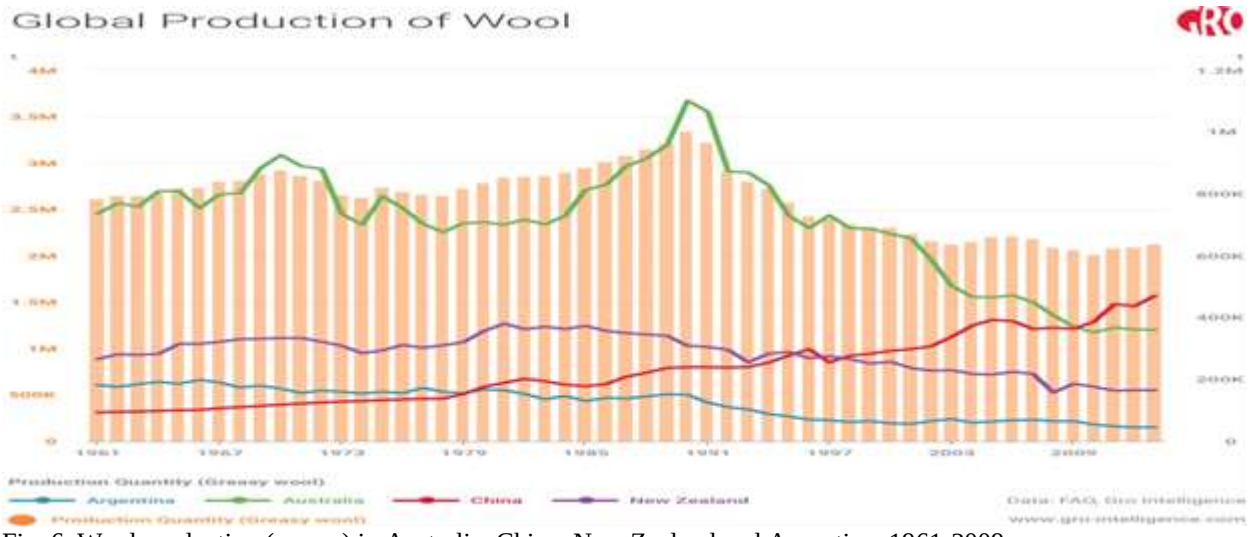

Fig. 6. Wool production (grease) in Australia, China, New Zealand and Argentina, 1961-2009
Source: [70].

A suggestive graphic reflecting a comparison regarding wool production (greasy) in Australia compared to China, New Zealand and Argentina is presented in Fig.6.

According to NSW Government, 2015, Wool Industry, Department of Primary Industry, Wool Industry and Future Opportunities, Supporting Papers, Paper 1: Trends and drivers for the global and Australian wool industry, besides Australia and China, there are other important wool processing and exporting countries such as:

-"Italy (second largest exporter of wool yarn, fabric, men's and women's woven wear and knitwear);
-India (largest exporter of carpets and rugs);
-Hong Kong (yarn and knitwear);
-the United Kingdom (fabric, knitwear, women's wear and carpets);
-Germany (fabric and men's wear);
-Bangladesh (knitwear);
-Turkey (men's wear, carpets);
-Romania (men's and women's wear);
-Spain (women's wear);
-USA (carpets);
-Belgium (carpets)".

The principal importing countries of wool products are: "the United Kingdom, Italy, the USA, Japan, China, Australia, and Germany". Their imports are oriented to:

- "the United Kingdom (men's wovenwear, women's wovenwear, knitwear, yarn, carpets);
-Japan (men's wovenwear, women's wovenwear, knitwear);
-Italy (yarn, fabric, knitwear);
-The USA (men's wool woven wear and women's wool woven clothing; wool carpets):
-China (yarn and fabric);
-Australia (carpets);
-Germany (men's and women's wovenwear, knitwear, yarn, carpets)" [46].

In the EU-28, wool has a different status and importance in the economy, practically it occupies almost the last position among the agricultural products, in fact, being considered a by-product.

In 2017, the EU-28 had 99.5 million sheep and goats, of which 86.8 million sheep and 12.7 million goats, the ratio being 6.8 sheep per one goat [15].

The sheep number declined since 2010 by 1.7% till 2017, the lowest level representing 96.4% of the 2010 level in 2012 and 2013.

In the EU-28, five countries are rearing 64.8 million sheep and 9.7 million goats, representing 75% of the EU sheep number and 76.5 % of its number of goats. It is about United Kingdom, which is on the top position, followed by Spain, Romania, Greece and France. While United Kingdom is the leader for the number of sheep (26.8%), Greece is the leader for the number of goats (29.9%). Smaller sheep and goats flocks are raised in other EU countries (Table 7).

Table 7. The number of sheep and goats in the EU-28 in 2017 (million heads)

	Sheep		Goats		Total sheep and goats	
	Million heads	Share (%)	Million heads	Share (%)	Million heads	Share (%)
EU-28	86.8	100.0	12.7	100	99.5	100.0
United Kingdom	23.3	26.8	0.1	0.8	23.4	23.5
Spain	16.0	18.4	3.1	24.4	19.1	19.2
Romania	10.0	11.5	1.5	11.8	11.5	11.5
Greece	8.6	9.9	3.8	29.9	12.4	12.5
France	6.9	7.9	1.2	9.4	8.1	8.1

Source: Own calculation based on Eurostat Data [15].

Despite of the existence of these species, in the EU, wool declined as importance, more than this climate change effects have become more visible year by year reducing the fodder production. As a result, the sheep number decreased, and the breed structure has been changed being oriented much more to meat production and milk production in the most rearing countries [49, 51, 54, 55].

For this reason, despite that sheep must be annually sheered in spring season to assure animal health, wool is not appreciated and

collected officially and it is not subsidized like other agricultural products.

To compensate the decline of the livestock during the last decade, the EU imports sheep and goats mainly from New Zealand and Australia. The two species are considered important only for maintenance of the landscapes and biodiversity preservation.

Sheep breeding is still running well in United Kingdom, Spain, Romania and France, but in United Kingdom wool accounts for 4% of all the kinds of fibers.

France is profiled on merino breeds producing high quality wool, while in Germany the number of sheep breeders decline as sheep are just hold for decorating and keeping the landscapes.

In the Central and Eastern European countries, sheep continue to be raised and the highest wool performance is carried out in Bulgaria, Hungary and Poland, and in a few measure in other countries like the Baltic ones, Czechia, Romania and Slovakia [45].

Sheep farming and wool processing is in a critical situation with a negative impact on the breeders' income, rural population living standard and rural economy. Transhumance is difficult to be practiced as long as the urban civilized penetrated in the rural areas.

Wool crisis continue to affect sheep breeders, and looking for solutions how to valorize wool, farmers started to process it locally into traditional products such as: carpets, blankets, coats, skirts, trousers, hats, gloves, collars, slippers etc. The products are traded locally or on the occasion of various organized fairs or folk events. Wool has become a marginalized product, despite the history proved that it contributed to the development of civilization in Europe, and still is the most important fiber of animal origin. The actual situation and future perspective of sheep and goats sector is discussed in the European Parliament in order to decide measures for sustaining sheep farming [22, 35].

In 2018, the ***United Kingdom*** had 34 million sheep producing 22, 000 tons wool, but the imports accounted for 42 million kg to cover the non manufactured textile wool fibers (greasy wool, degreased wool, carbonized wool and waste) [67]. The United Kingdom is one of key exporting countries in the world of woolen fabric, knitwear, women's wear and carpets, and an importing country of woolen men's and women's wovenwear, knitwear, yarn, carpets [46].

Italy is the 2nd exporting country in the world of wool yarn, fabric, men's and women's woven wear and knitwear, being far away from Germany, Japan, South Korea and Czechia. Italy is alos an important importing country of yarn, woolen fabrics and knitwear, mainly from China, Germany, Romania, Japan, Turkey and Morocco [24].

Germany is an exporting country of fabric and men's wear, and an importing country of men's and women's wovenwear, knitwear, yarn, carpets [46].

France is both an importing and exporting country of wool yarn or fine animal hair, the exports being oriented mainly to the USA, United Kingdom, Germany and small amounts to China. France also exports yarn of carded wool to Spain, Morocco, Switzerland, Romania, China, Netherlands, Germany and Italy.

Spain produced 4.7 k tons wool in 2018, by 34% more than in 2017, after the decline in 2012. In 2018, Spain exports increased by 52 % compared to 2017, about 62 % wool being sold in Italy, Denmark, Portugal, Belgium, United Kingdom, France and Germany. In 2018, Spain's wool import was by 29.7% smaller than in 2017, the main suppliers being Portugal, United Kingdom, and Morocco [66].

Romania had in 2018 a number of sheep and goats accounting for 10.17 million heads, and, respectively, 1.51 million heads, from which it was obtained a total unwashed raw wool production of 24.4 thousand tons. In 2017, it obtained 36 thousand tons.

Taking into account the new orientation to meet and milk production, wool remained on the 3rd position, and wool price become very low leading to the dissatisfaction of the sheep breeders who had no opportunities to sell wool [49, 51, 54].

For sustaining the sheep breeders, the Romanian Government decided since 2017 to offer a financial aid of Lei one per

commercialized wool and established the centers for wool collection [36].

Raw wool is processed by industrialized companies into woolen men's and women's wear which are successfully exported [28, 46]. Because of the huge amount of wool produced in the country, scientific research developed new projects for identifying other opportunities for wool valorization. In this respect, it was launched a business in producing wool thermo isolations in buildings industry [79]. In Romania there is also a private company named TOLGA dealing with wool cleaning. Wool of various types is collected from the local producers and also imported from Hungary, Libya, Bulgaria, Georgia, Greece and Turkey. The company's export is represented raw unwashed and raw cleaned wool to the United Kingdom, Italy, Spain, Portugal, Germany, Hungary, Pakistan, Ireland and China [69]. Also, raw wool is locally manufactured into traditional handicrafts: sheepskins coats, carpets, blankets, pullovers, trousers, skirts, collars, gloves, slippers etc which are well appreciated by consumers.

CONCLUSIONS

Despite that the world market is dominated by the synthetic fibers, natural fibers still account for 35 % in the global fiber production. The demand for natural fibers is increasing grace to their special qualities: naturalness, comfort, pleasant touch, breathability, durability, elasticity, moisture absorbance, protection against heat and cold, suitability for recycling and environment protection, and also due to their large range of products. Cotton is the most utilized natural fiber of plant origin and wool and silk are the most important fibers of animal origin.

The paper analyzed the dynamics of natural fibers production of animal origin in the period 2007-2018 to identify the major trends in production, but also in export and import.

In 2018, the world silk production accounted for 159,648 metric tons being by 32.11 % higher than in 2007. The main producing countries are China and India representing 97.19 % of the world silk output. China and India are also exporting and importing countries, while the USA, Italy, Japan, India, France, China, United Kingdom, Switzerland, Germany are the principal importing countries of silk products. Romania is also among the top silk exporting and importing countries.

The world wool production (clean) declined from 1,202 thousand tons in 2007 to 1,155 thousand tons in 2018, due to the reduction of sheep population from 1,100 million heads in 2007 to the lowest level in 2015 but then it started a slight recover in 2018, reaching 1,177 million heads. The new orientation in Europe to meat production has deeply affected sheep breeders' income as wool price declined, sheep farming being justified just foe meat and milk but also for maintaining the landscapes and environment protection.

The main wool producing countries worldwide (clean equivalent) are: Australia, China, New Zealand, CIS, Argentina, United Kingdom, South Africa and Uruguay.

The consumption of wool fibers is distributed as follows: 48 % apparel wool, 31 % interior textiles and 21% industrial wool.

Australia exports garments, sweaters, men suits and women overcoats, China exports yarn and knitwear, Italy is the 2nd exporter of wool yarn, fabric, men's and women's woven wear and knitwear, India is the largest exporter of carpets and rugs, the United Kingdon is profiled on fabric, knitwear, women's wear and carpets.

The main importing countries of processed wool are: the United Kingdom, Italy, the USA, Japan, China, Australia, and Germany.

The analysis allowed to draw the conclusion that natural fibers of animal origin are required by consumers and their demand is increasing and this encourages producers and traders to intensify production and international trade to better satisfy clients' needs.

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